DOCUMENT RESUME

ED 441 672 SE 063 555

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TITLE Implementing Student-Centered Instruction in Korean and the U.S. Elementary Mathematics Classrooms.
PUB DATE 2000-04-26
NOTE 15p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cross Cultural Studies; *Educational Change; *Elementary School Teachers; Foreign Countries; Mathematics Instruction; *Mathematics Teachers; Primary Education; *Social Influences; Teaching Methods
IDENTIFIERS *South Korea; *United States

ABSTRACT

This study compares and contrasts the classroom social norms of two Korean and two U.S. second grade teachers who aspired to implement reform. Despite similar social participation structures, the two classes within each country were remarkably different in terms of sociomathematical norms. In one class in each country, students experienced mathematics on the basis of a rather fixed procedure that the teacher consistently emphasized. The students' mathematical ways of thinking and valuing were limited to finding out the pre-determined rules. In contrast, the students in the other classes learned mathematics on the basis of their own sense-making processes. A specific solution method or idea was scarcely emphasized over students' various ways of approaching a given mathematics problem. The students were continually engaged in significant mathematical processes by which they could develop an appreciation of characteristically mathematical ways of thinking, communicating, arguing, proving, and valuing. The similarities and differences between the two teaching practices within each country clearly indicate that students' learning opportunities do not arise from the general social norms of a classroom but from its sociomathematical norms. This study also supports the growing realization of the reform community that reforming mathematics teaching is neither a matter of changing the social structure of instruction nor of adding a few new techniques to an existing repertoire. (Contains 57 references.) (ASK)

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Implementing Student-Centered Instruction in Korean and the U.S. Elementary Mathematics Classrooms

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Background to the Study

The Third International Mathematics and Science Study (TIMSS) reports dramatically different mathematics achievement of fourth- and eighth-grade students between Korea and the United States (Mullis, Martin, Beaton, Gonzalez, Kelly, & Smith, 1997; NCES, 1996). Ironically, despite the differences in mathematics achievement, problems in Korea and the U.S. with regard to mathematics education are perceived to be very similar. The problems include learning without understanding of mathematical ideas (Hiebert, Carpenter, Fennema, Fuson, Human, Murray et al., 1997; Noh, 1998) and increasingly negative mathematical disposition as students advance through school (Kim, Kim, Lyou, & Im, 1996; Renga & Dalla, 1993).

There are many cross-national differences in the culture of education and in the structure and organization of curriculum and instruction which can account for the unequal performance between Korean and the U.S. students (NCES, 1996, 1997). However, the shared problems have a common origin in teacher-centered instruction perceived as modal in the two countries (Kim et al., 1996; Mullis, et al, 1997; Noh, 1998; TIMSS, 1996). The term *teacher-centered* refers to a teacher's explanations and ideas constituting the focus of classroom mathematical practice. Against these common instructional practices, educational leaders in both countries have persistently attempted to change the teacher-centered pedagogy to a student-centered approach (Kang, 1998; Ministry of Education, 1992, 1997; NCTM, 1989, 1991, 1995, 2000). The term *student-centered* refers to students' contributions and responses constituting the focus of classroom practice.

Many teachers report familiarity with and adherence to reform ideas, but their actual classroom teaching practices do not reflect a deep understanding of reform (Hiebert, Carpenter, Fennema, Fuson, Human, Murray, et al., 1996; NCES, 1996; Research Advisory Committee, 1997). Their methods tend to reflect only the surface social practices of the recommended methods (Cohen, 1990; Peterson, 1994). Teachers too easily adopt a new teaching techniques, but without reconceptualizing how such a change in teaching strategies relates to fostering students' conceptual understanding or mathematical dispositions (Burrill, 1997; Stigler & Hiebert, 1998).

Cobb and his colleagues developed an "emergent" theoretical framework that fits well with the reform agenda for instruction (Cobb & Bauersfeld, 1995). In this perspective, mathematical meanings are seen as emerging in a continuous process of negotiation through social interaction. In investigating students' mathematical learning within the emergent perspective, Cobb and his colleagues addressed *sociomathematical norms* as "the normative aspects of whole-class discussions that are specific to students' mathematical activity" (Cobb & Yackel, 1996, p. 178). They differentiate general social norms as applicable to any subject matter area from sociomathematical norms which are unique to mathematics. The examples of sociomathematical norms have included the norms of

what count as an acceptable, a justifiable, an easy, a clear, a different, an efficient, an elegant, and a sophisticated explanation (Bowers, Cobb, & McClain, 1999; Cobb, Gravemeijer, Yackel, McClain, & Whitenack, 1997; Yackel & Cobb, 1996).

Recent cross-national comparative studies of mathematics education incorporate qualitative interest with quantitative-oriented investigation (e.g., Easley & Taylor, 1990; ICTM, 1989; Schmidt, Jorde, Cogan, Barrier, Bonzalo, Moser, et al., 1996; Stevenson & Stigler, 1992; Stigler, Fernandez, & Yoshida, 1996; Stigler, Lee, & Stevenson, 1990; TIMSS, 1996; Yang & Cobb, 1995). The common objective of these studies has been to compare general social norms of typical mathematics classes across countries. These comparisons have provided a more explicit understanding of each country's own Characteristic Pedagogical Flow (CPF), recurrent national patterns of teaching practices and learning activities, reflecting typical conceptions of instruction within the country (Schmidt, et al., 1996).

Although comparison of typical classrooms can make a valuable contribution to understanding the dynamics of teaching in a country, it may not always contribute directly to attempts to implement teaching reform. Even when such contributions are possible, they may not be equitable for all countries. This study departs from past international comparisons by focusing on student-centered classrooms in each country. Because the goals of reform (as articulated in U.S. and Korean reform documents) are so similar, we can expect that each country can learn much from the successes and the failures of the other. As LeTendre (1999) noted, countries that are as culturally different as Korea and the U.S. are the best choices for a study on what is culturally relevant with regard to education.

Research Project

Objectives and Methods

Given the challenges in implementing reform, this study intended to explore the breakdown that may occur between teachers' adoption of reform objectives and their successful incorporation of reform ideals. To this end, the study compared and contrasted the classroom social norms of two Korean and two U.S. second-grade teachers who aspired to implement reform. The two classrooms in each country were chosen because of their unequal success in activating the reform recommendations. The comparison and contrast between more successful and less successful reform classes provided a unique opportunity to reflect on possibly subtle but crucial issues with regard to reform implementation. Since the principal concern of reform is to connect changes in teaching practices with changes in learning opportunities that students will encounter in the class, students' learning opportunity was analyzed in the target classrooms.

This study was an exploratory, qualitative, comparative case study (Yin, 1994) using grounded theory methdology based on *constant comparative analysis* (Glaser & Strauss, 1967; Strauss & Corbin, 1998) for which the primary data sources were classroom video recordings and transcripts (Cobb & Whitenack, 1996). A central feature of this method is to compare and to contrast preliminary inferences with new incidents in subsequent data in order to determine if the initial conjectures are sustained throughout the data set. The process of comparisons and contrasts makes provisional inferences stable or elevates them to become powerful explanatory constructs.

Data Collection and Analyses

The Korean portion of this study was conducted by the team of four researchers (including the author) and partly presented in recent AERA meetings (Kirshner & Pang, 1998; Pang & Kirshner, 1999; see also Kirshner, Jeon, Pang, & Park, 1998 for a more complete account of the Korean classes). The team observed one dozen mathematics lessons in schools attached to universities, in schools nominated as research schools, or in classes recommended by district supervisors. Whenever an observed class appeared to implement a student-centered approach, the team conducted brief interviews with the teacher focusing on her or his teaching philosophy. Finally, two second grade classes in Cheongju were agreed upon by the four researchers. The classes were selected because of their unequal success in implementing student-centered teaching methods.

A few mathematics lessons, in each classroom, were video-taped using three video cameras to capture the teaching and learning practices from different perspectives: One for the teacher, another for the students, and the third for the classroom setting as a whole. In addition, audiotapes were used to capture the students' conversation in small groups. Moreover, field-notes of general classroom activities were written and individual students' worksheets were collected after each class. A total of 12 videotapes and 12 audiotapes were used for analyses of classroom teaching practices. Video- and audio- taped lessons have been transcribed and translated. Also in-depth interviews with the teachers were conducted as an attempt to explore mainly how she developed her own teaching approaches.

The U.S. portion of this study and joint analysis were conducted by the author as her dissertation project. A similar research design was used. After preliminary observations of 17 recommended classrooms in Baton Rouge, two second grade classes were selected because of the inequality in the extent that students' ideas were solicited and became the center of mathematical discourse. A total of 14 math lessons were videotaped, audio-taped, and transcribed. Additional data were collected from the students' projects and the interviews with the teachers.

The purpose of exploratory study is to articulate new issues and problems, rather than to definitively answer questions (Yin, 1993, 1994). The small number of classes, and small number of observations of each class, do not provide a basis for firm generalization. However, qualitative case study is well established as a methodology for generating theoretical and empirical insights to be pursued in subsequent broader based studies (Yin, 1994). Particularly, large scale crossnational research can benefit greatly from previous exploratory research in which the international team has the opportunity to identify, dispute, and achieve consensus on the key issues of the investigation (Schmidt et al., 1996).

Data analyses for this study have three stages: Individual analysis of each classroom setting, comparative analysis of two different classes within country; and cross-national comparative analysis. Interview data are included in the analyses of classroom teaching practices when they provide useful background information. Individual analysis characterizes general social norms and sociomathematical norms, which concern the specifically mathematical knowledge and understandings of the classrooms embedded within the general social norms (Cobb & Bauersfeld, 1995; Yackel & Cobb, 1996). Next,

the data from the individual classes are employed for comparisons and contrasts within each country. This second analysis also identifies the underlying factors which significantly influence the teacher's instructional goals from interview data. Specifically, the author focuses on the difficulties and successes of the two teachers, and formulates issues and obstacles that may point toward generic problems of reform in each of the two countries. Finally, this study moves on to cross-national consideration.

Results

Despite the limitations of exploratory research, a clear and convergent picture of each classroom teaching practice emerged from the analysis. Portraits of the teaching practices observed in the Korean classrooms are presented along with portraits of the two U.S. classrooms. The two Korean teachers are identified as Ms. G (in Class KG) and Ms. C. (in Class KC). The two U.S. teachers are identified as Ms. E (in Class UE) and Ms. M. (in Class UM).

Mathematics Teaching and Learning in Ms. G's Classroom

In many ways, Ms. G in Korea encouraged students' participation in order to make their ideas and judgments the focus of classroom attention. For instance, she lavished praise and positive expectations on the students, organized a variety of classroom participation structures, asked for explanations, different methods, and critiques of previous methods, stressed the importance of sharing ideas and collaborating in small groups, and frequently repeated or rephrased students' explanations for the whole class.

Despite these compelling social norms that are generally consistent with student-centered pedagogy, Ms. G's consistent focus remained the procedural methods for accomplishing various tasks, and the correctness of the answers. For instance, when Ms. G criticized one student's presentation in which she used the word "vertical lines" instead of naming the place values, Ms. G never probed the nature of the student's conceptual understanding. Ms. G seemed satisfied that another student was able to provide a better vocabulary, "digit by digit", and quickly changed the subject of discussion. Indeed, the two students' explanations were the same in terms of their conceptual understanding.

Throughout her lesson, Ms. G emphasized using different methods to solve a given problem and welcomed all students' solutions as being different. There was little discussion of what counts as mathematically different, or even of why using different methods is important. Toward the end of the class, Ms. G consolidated and summarized standard subtraction algorithm as the "convenient" method, after listening to various methods presented by students. What was mathematically significant in this classroom was getting the correct answer and giving presentations using the recommended standard algorithm.

The students' main approach in Ms. G's class was to comply with the teacher's expectations rather than to pursue their own understandings. Owing to the teacher's general emphasis on their participation, the students sometimes provided criticism and question but those were limited to procedural aspects of the mathematical content being considered. As a result of Ms. G's and their

own approaches, students learning opportunities tended to be limited to procedures for correctly adopting standard algorithms.

Mathematics Teaching and Learning in Ms. C's Classroom

Ms. C in Korea established similar social norms similar to Ms. G's, in that students' ideas constituted the central concern of lessons. Ms. C especially emphasized that students should solve a given subtraction problem for themselves in many different ways. She carefully observed students' individual or collective work and picked out mathematically insightful contributions for presentation in the subsequent whole class discussion. An example was that she became very excited when a group of four students developed the use of arbitrary units in representing numbers. They decided to regard a bundle of 10 chopsticks not as 10 but as 100. Another crucial episode revealing Ms. C's teaching approach was when she guided a mathematics discussion through which students had a chance to understand what was the mathematical difference between using coins and using tiles — iconic representations only symbolize the relative quantities through unequal sizes of the coins, whereas concrete representations actually embed the quantitative relations in the physical structure of the tiles.

Note that Ms. C, like Ms G, asked for different solution methods to solve a problem and encouraged students to present their invented methods. But rather than applauding all contributions equally, Ms. C carefully selected mathematically significant contributions as described above. In this way, Ms. C initiated and guided development of a sociomathematical norm for what counts as a mathematically different explanation.

The students in Ms. C's classroom not only complied with her demands for participation, but even tried to invent their own mathematical ideas and to participate fully in their group activities. In these approaches, the students had the learning opportunity to construct significant understandings of mathematical concepts: differences between iconic and concrete representational modes, the take-away interpretation of subtraction, and the arbitrariness of the unit in arithmetic representations. Moreover, there was evidence of students becoming self-motivating in their pursuit of mathematical meaning. For instance, some of the students continued to work on figuring out solutions even after the teacher had rung the bell to signal a new activity.

Mathematics Teaching and Learning in Ms. E's Classroom

Like the two Korean teachers, Ms. E in the U.S. was successful in establishing classroom social norms compatible with a student-centered approach. Among other things, Ms. E actively facilitated students' participation in the classroom mathematics activities and discussions by employing enjoyable formats, emphasizing visualization of the given problem situations, giving students many opportunities to solve problems individually or collectively and to present their methods to the class, expressing excitement about students' novel ideas, and asking students to author story problems within a group.

Despite this exemplary *form* of student-centered instruction, the content and qualities of Ms. E's teaching focussed primarily on procedural knowledge. To be clear, in some cases, Ms. E expressed her interest in conceptuality but those cases were somewhat infrequent. Ms. E listened to

students' various contributions but usually turned out to control the classroom discourse toward one direction — using standard algorithm or a specific equation for a given mathematics problem. This concern occurred across different classroom activities. For instance, in an estimation activity, when a student presented his own mathematical reasoning to solve 100-88, Ms. E praised him but immediately guided students to use formal algorithm. She frequently initiated classroom discussions by saying, for example "what's the *first* thing I do [to solve this problem]?", which signaled that students were expected to attempt to add or subtract from the ones column. In a problem solving activity, Ms. E solicited students to solve a problem but reinforced their use of specific equations, even after they provided mathematically reasonable alternative methods. As well, Ms. E often provided her own solution strategies or ideas.

Reflecting Ms. E's practices, students often expressed keen excitement when they got right answers. But they sometimes waited for their teacher's confirmation rather than develop their own rationales or arguments while engaged in group activities. As a result of Ms. E's and of their own approaches, students' learning opportunities were somewhat limited to acquire procedural skills to solve routine problems with accuracy and confidence. Whereas the students were actively involved in classroom mathematical activities, they had little chance to develop the mathematical understandings that could inform their activities. In these respects, the important sociomathematical norms of this class included mathematical accuracy and automaticity.

Mathematics Teaching and Learning in Ms. M's Classroom

Ms. M in the U.S. also established classroom social norms by which students' contributions and ideas were focused. Like Ms. E, she was concerned about students' participation in classroom mathematical activities and discussions. Unlike Ms. E, Ms. M focused on students' own sense-making processes while they were participated in the classroom community. Her primary interest was to create an effective classroom community in which students invent, explain, and justify their own solution methods or ideas. Ms. M encouraged her students to argue or debate for extended periods of time — especially when there were competing solution methods or ideas — rather than providing her judgement. Only after students' full contributions to the discussion did she summarize the main argument in each position.

While focusing on students' mathematical thinking, Ms. M urged them to specifically mathematical ways of valuing and communicating. Producing only a correct answer without a mathematically justifiable process was rejected. For instance, a student knew the answer for 42-26 because the class solved it using unifix cubes. When the student presented his numerical solution method, he claimed to take away 4 more after subtracting 20 from 40. As he was not able to provide mathematical evidence of taking away 4 more, Ms. M did not accept his contribution as valid. Similarly, merely recalling a multiplication fact from a times table seen at home, without a mathematical explanation, was not valued.

In conjunction with Ms. M's approach, her students tended to use their own ways of approaching a given task both in whole group and in small group settings. Moreover, they were often engaged in mathematical debates without the teacher's initiation or mediation. In these approaches,

the students had the learning opportunities to construct conceptual underpinnings of the mathematics they were studying, even as they were continually exposed to mathematically significant ways of knowing, valuing, and arguing.

Discussion

Importance of Sociomathematical Norms

The four classrooms presented above established very similar social norms including an open and permissive learning environment, stressing group cooperation, connecting concrete representation by manipulative materials to numerical computation process, employing enjoyable activity formats for students, orchestrating individual or small group session followed by whole group discussion, emphasizing multiple solution methods, expecting students' active participation, and providing the teacher's amplication of students' contributions. These are general social norms that are compatible with current reform recommendations (Ministry of Education, 1992, 1997; NCTM 1989, 1991, 1995, 2000).

Despite these similar social participation structures, the two classes within each country were remarkably different in terms of sociomathematical norms. In one class (KG from Korea, UE from the U.S.), students experienced mathematics on the basis of rather fixed procedure the teacher consistently emphasized. The students' mathematical ways of thinking and valuing were limited to find out the pre-determinded rules. Similarly, their mathematical ways of arguing and justifying were concerned mainly with following the rules, rather than with their own sense-making. In these respects, being accurate or automatic was evaluated as a more important contribution to the classroom community than being insightful or creative. In contrast, the students in the other class (KC from Korea, UM from the U.S.) learned mathematics on the basis of their own sense-making processes. A specific solution method or idea was little emphasized over students' various ways of approaching to a given mathematics problem. The students were continually engaged in significant mathematical processes by which they could develop an appreciation of characteristically mathematical ways of thinking, communicating, arguing, proving, and valuing.

The similarities and differences between the two teaching practices within a country clearly show that students' learning opportunities do not arise from general social norms of a classroom community. Instead, they are closely related to its sociomathematical norms. Thus, this study suggests that reform efforts highlight the importance of sociomathematical norms that become established in the classroom microculture. It was apparent from this study that sociomathematical norms are an important construct reflecting the quality of students' mathematical engagement and anticipating their conceptual learning opportunities.

Implications for Reform: Embracing Diversity

This study supports the growing realization of the reform community that reforming mathematics teaching is a matter neither of changing the social structure of instruction nor of adding a few new techniques to an existing repertoire. Rather it involves reconceptualizing how students' engagement in the social fabric of the classroom may enable them to develop increasingly sophisticated ways of mathematical knowing and valuing. This reconceptualization never comes

easily, even for teachers who are dedicated and committed to aligning their teaching practices to reform. Ms. E's case in the U.S. and Ms. G's case in Korea warn of the possibility that simply changing classroom social norms promotes neither students' conceptual learning opportunities nor their social engagement toward characteristically mathematical ways of thinking and communicating. Although the students in both of these classrooms had positive and enjoyable experiences in their mathematics classes, opportunities for enhancing their specifically mathematical development were somewhat limited. Ms. M's case in the U.S. and Ms. C's case in Korea show the possibility that students may acquire conceptual underpinnings of mathematics they are studying as they actively participate in the social processes which include explanation, justification, argumentation that are specific to mathematical activity and discourse. This is a case where reform efforts turn out to be successful. In this respect, the construct of sociomathematical norms, not general social norms, should be focused for initiating and evaluating mathematics education reform efforts as they occur at the classroom level.

Current reform emphasizes students' development with regard both to specific mathematical content and to mathematical dispositions (NCTM, 1989, 1991, 1995, 2000). The transition from students' conceptual development to its incorporation with social development has remained challenging both theoretically and practically (Anderson, Reder, & Simon, 1996, 1997; Confrey, 1995; Greeno, 1997; Kirshner & Whitson, 1998; Lerman, 1996, 1997, 2000; O'Connor, 1998; Sfard, 1998; Steffe & Thompson, 2000). A unitary conception of reform has been cited as a potential *problem* of the reform movement (Lindquist, Ferrini-Mundy, Kilpatrick, 1997).

The classroom analyses of the teaching practices Ms. M in the U.S. and Ms. C in Korea reveal very different models of successful reform implement. As described above, Ms. M's pedagogical priority was to create a learning environment in which students were able to engage in significant mathematical discussions. She rarely considered the implications or conceptual subtleties of what her students came up with. Rather, she focused on whether her students had the opportunity to build their own mathematical understanding as they participated in the classroom activity and discourse. When compared with Ms. C's class (see below), Ms. M seemed to be more successful in establishing a more empowering classroom mathematical community owing to her more focused interest in students' mathematical socialization. There was much evidence in Class UM that students were becoming self-motivating in their pursuit of mathematical meaning. The examples included students' request for clarification of the problems/game situations given by Ms. M, their frequent debates from different interpretations without Ms. M's initiation or guidance, and their persistence in developing and using their own solution methods both in whole group and in small group settings.

Ms. M was heavily influenced by traditional interpretations of Piaget's work. She emphasized that learning for little children is play, and that early introduction of standard algorithms was developmentally inappropriate. While her pedagogical priority was to promote students' positive dispositions (socialization) toward mathematics, Ms. M did not completely discard her interest in conceptuality. Influenced by this Piagetian interpretation, Ms. M saw herself as a facilitator rather than initiator of teaching mathematical content. But she discharged her concern for content by carefully soliciting the contributions of stronger students in cases where the risk of conceptual

confusion was high. From an individualist perspective, this teaching technique might be seen as creating a hierarchy among the students according to the various roles instituted by the teacher. But Ms. M herself seemed to have a communitarian perspective in which the well being of the individuals in the class was a function of the successes and failures of the class as a whole.

Whereas Ms. M was constrained by Piagetian assumption in teaching specific mathematical content, Ms. C from Korea was much more willing to mediate classroom discourse for students' conceptual development. Unlike Ms. M, in the course of supporting students' mathematical engagement and discussion, Ms. C developed a specific *conceptual* agenda for use of different materials. When compared with Ms. M's class, the quality of mathematical content dealt with in Ms. C's class was much more sophisticated. Ms. C masterfully attended to concordance between the social processes of the classroom and students' engagement toward development of specific mathematical concepts.

Ms. C began with a subtraction problem and emphasized solving the problem with different methods. Her students contributed to the classroom discourse through their invention, explanation, justification, and argumentation of various solution methods. Meanwhile, the students had the opportunity to experience characteristically mathematical ways of thinking and communicating that had been established in the classroom community. Ms. C paid careful attention to her students' mathematical understandings embedded in solving and discussing the given subtraction problem. The students became more sophisticated with regard to what constitutes mathematically different. Based on their individual and collective activity of solving one problem using various manipulative materials, Ms. C initiated and orchestrated discussion in ways that allowed the students to develop a mathematically significant concept, that is the difference between concrete and iconic representational systems. The understanding of what makes a solution mathematically different was embedded within the activity structure of the lessons. Indeed, the concept was addressed not by the teacher's authoritative knowledge but by the students' participation in the classroom practices. Students' engagement in the task was central to compare and contrast different representational modes. Ms. M's and Ms. C's teaching practices reveal the successful aspects of implementing reform ideals but in different ways — focusing primarily on students' mathematical engagement and coordinating classroom social processes with students' conceptual development.

Recall that there were similar aspects in Korea and the U.S. with regard to comparison and contrast between a more successful and a less successful mathematics classroom. This observation provides a more caution for the Korean reform movement than for its U.S. counterpart. The characteristics of typical Korean mathematics teaching practices included teacher-centered whole class instruction in a systematic, coherent, and progressive way (Grow-Maienza et al., 1999). In general, whole-class teaching by well-prepared, skilled teachers in East Asia are appreciated in comparison to western individualized instruction (Stevenson & Lee, 1995). The prevalent Korean teacher-centered teaching method has contributed at least to students' superior mathematical achievement in international contexts. As reviewed above, it was compelling for Korean mathematics educators to advocate instructional changes from teacher-centered toward student-centered pedagogy. However, any kind of rash implementation of such changes may lead to lose the current

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well-structured Korean teaching practices and, to make it worse, the changes may not promote students' conceptual understanding of mathematics as intended. Given this, changing teaching practices should be conducted with great delicacy and consideration in Korea.

Reform is fundamentally about significant change, and the teacher remains the key to change. The extent to which significant change occurs depends a great deal on how the teacher comes to make sense of reform and respond to it. It is not an overstatement that real instructional change occurs only at the classroom level, as teachers grapple with their own values and priorities relative to the ideals promoted for the profession. Teachers need to be empowered in developing alternatives or integrating different aspects of reform agenda with regard to their own diverse pedagogical motivations (Kirshner, in press). This study paves a way by which teachers and reformers open towards diverse but viable mathematics teaching approaches that are compatible with the current reform recommendations.

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